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1.	Your reference	RSJ07617GB
2.	Patent application number *(The Patent Office will fill in this part)*	06 NOV 2002 0225898.6
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Oxford Instruments Superconductivity Limited Old Station Way, Eynsham Witney, Oxon, OX8 1TL GREAT BRITAIN
	08189367001 Patents ADP number *(if you know it)*	
	If the applicant is a corporate body, give the country/state of its incorporation	Great Britain
4.	Title of the invention	APPARATUS FOR USE IN NMR SYSTEM
5.	Name of your agent *(if you have one)*	Gill Jennings & Every
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Broadgate House 7 Eldon Street London EC2M 7LH
	Patents ADP number *(if you know it)*	745002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
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YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	5
Claim *(s)*	2
Abstract	
Drawing *(s)*	3 +3 RM

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	NO

11. For the applicant
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 06/11/02

12. Name and daytime telephone number of person to contact in the United Kingdom — SKONE JAMES, Robert Edmund
020 7377 1377

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APPARATUS FOR USE IN NMR SYSTEM

The invention relates to apparatus for use in a NMR system, the apparatus comprising a magnetic field generator surrounding a bore, for generating a magnetic field in a working volume located in the bore; a sample support which can be removably inserted into a first end of the bore so as to locate a sample in the working region; a probe carrying RF generating and receiving coils and which can be removably inserted into the other, second end of the bore so as to locate the RF coils adjacent the working volume; and a set of shim coils located in the bore about the working volume and which cooperate with the magnetic field generator to create a magnetic field in the working volume of sufficient uniformity to perform a NMR experiment on a sample. Such apparatus is hereinafter referred to as of the kind described.

Apparatus of the kind described is manufactured and sold by Oxford Instruments Superconductivity Limited.

There is a continuing need to design apparatus of the kind described with increasingly higher magnetic field strengths and this requires significant additional space to accommodate windings of the magnetic field generator which is undesirable, increased cost because of the extra conductor required and more complex quench energy management.

In accordance with the present invention, NMR apparatus of the kind described is characterized in that the RF receiving and generating coils are located in a reduced diameter section of the probe at its leading end; and in that at least some of the shim coils are located on a support surrounding the reduced diameter section of the probe.

We have realised that an important factor in the overall size of the apparatus is the diameter of the bore. Typically, each millimetre of saved bore space can equate to a significant radial decrease in the windings making up

a coil defining the magnetic field generator. Further, we have realised that although the probe carries many conductors and control lines in conventional arrangements, typically up to 80 or even more, together with tuning circuits and power capacitors and thus needs the full width of the bore to accommodate these components, the components which need to be located adjacent the working volume require less radial space and thus can be accommodated within a reduced diameter section of the probe. This in turn releases a space radially outward of the reduced diameter section of the probe which can be used to accommodate shim coils. As a result, it is possible to accommodate the components of the apparatus into a smaller diameter bore with the advantages mentioned above.

Although the shim coils support could be separate from both the probe and the sample support, preferably the two are coupled, typically integrally formed. In the past, the sample support or "top tube" has merely served to support the sample but in this preferred aspect, it can also be used to support the or some of the shim coils and contain the power lines needed to couple the shim coils with a power supply.

In some examples, all the shim coils are provided on the shim support but in some cases, either the axial field shim coils or the radial field shim coils could be located within the reduced diameter section of the probe. This is a matter of design choice and has the advantage that some aspects of a conventional probe with a shim coil power supply could be used.

Typically, the sample support includes a tube and as in conventional arrangements, this may include a mechanism for rotating the sample within the working volume.

The magnetic field generator can take any conventional form and could include a permanent magnet but typically is defined by a superconducting coil of either low or high temperature superconductor. In these cases, the coil will be housed within a cryostat in a conventional manner.

Some examples of apparatus according to the invention will now be described and contrasted with known apparatus with reference to the accompanying drawings, in which:-

Figure 1 is a schematic, longitudinal section through known NMR apparatus;

Figure 2 is a view similar to Figure 1 but of a first example of apparatus according to the invention; and,

Figure 3 is a view similar to Figure 1 but of a second example of the invention.

The apparatus shown in Figure 1 will be connected in use to conventional NMR processing components (not shown) and comprises a main magnetic field generator 1 constituted by a superconducting coil located within a cryostat 2. Typically, the coil 1 will be maintained at liquid cryogen, e.g. helium, temperatures. The cryostat 2 defines a room temperature bore 3 arranged vertically as shown in Figure 1. A probe 4 is removably inserted into the bore 3 from its lower end 5, the probe mounting within it an RF generating coil 6 and RF receiving coils 7,8. The probe 4 is tubular and surrounds a space 9 defining a working volume within which a sample 10 is located in use. The sample 10 is contained within a tube 11 mounted to an outer, top tube 12 removably inserted through the top 13 of the bore 3. The top tube 12 has a reduced diameter section 14 which supports a spinner mechanism 15 to which the tube 11 is attached. The spinner 15 can be driven to rotate within the reduced diameter section 14 of the top tube 12 so as to rotate the tube 11 and hence the sample 10.

The RF generating coil 6 is coupled via wires (not shown) with RF electronics and power source 16 while the RF receiving coils 7,8 are also connected to the electronics 16 to enable received RF signals to be processed.

The probe 4 also supports gradient coils shown schematically at 17, these gradient coils being powered from a power source 18.

A set of shim coils 19 are arranged concentrically about the working volume 9 and are powered from a shim coil

power source 20 through wires extending through the bottom opening 5 of the bore 3.

The top tube 12 and probe 4 can be removed from the bore and reinserted without having to purge the cryostat 2.

As explained above, the problem with this known arrangement is the wide diameter required for the bore 3 in order to accommodate all the components.

A first example of apparatus according to the invention is shown in Figure 2 and components which are similar to those shown in Figure 1 have been given the same reference numerals and will not be further described. As can be seen, in this case, the probe 4' has a reduced diameter section 21 at its leading end surrounding the working volume 9. Within this reduced diameter section 21 are located the RF coils 6,7 and gradient coils 17. The more bulky components which need to be carried within the probe are located in the wider diameter section 22 of the probe.

In this example, the shim coils 19 are mounted on a support constituted by a tubular extension 23 of the top tube 12, the radial dimension of the tubular extension 23 being substantially equal to the difference in radial dimension of the small and large diameter sections 21,22 of the probe. Power from the shim coil source 20 is communicated to the shim coils 19 through the top tube 12.

As can be seen by comparing Figures 1 and 2, the components have been much more efficiently mounted so that a narrower bore 3 can be used. An example of the reduction which can be achieved is from a bore diameter of 54mm to a bore diameter of 49mm while achieving the same probe functionality. This will result in a significant reduction in the diameter of the magnet 1 and so the stored energy of the magnet will be significantly less than in the conventional design.

In the Figure 2 example, the shim coil support 23 was integral with the remainder of the top tube 12. In an alternative design (not shown), the support 23 could be

separate from the top tube 12 but power would still normally be supplied to the shim coils through the top 13 of the bore 3.

In the examples mentioned so far, the shim coils have been located in their entirety on the shim coil support 23. Figure 3 illustrates a modification in which some of the shim coils 24 are located within the reduced diameter section 21 of the probe 4'. (Again, in Figure 3, those components which are the same as in Figures 1 and 2 have been given the same reference numerals.) Thus, as can be seen in Figure 3, some shim coils 24 are mounted within the reduced diameter section 21 of the probe. In one example, the axial shim coils are located in the probe and radial shim coils 19' in the support 23. In another arrangement, this can be reversed. In addition, in each of these cases, the support 23 may be integrally formed with the top tube 12 (as shown) or separate from it.

Where some of the shim coils are mounted in the probe as shown in Figure 3, an additional shim coil power source could be provided but in the preferred arrangement (Figure 3), a single source 25 is used.

CLAIMS

1. Apparatus for use in a NMR system, the apparatus comprising a magnetic field generator surrounding a bore, for generating a magnetic field in a working volume located in the bore; a sample support which can be removably inserted into a first end of the bore so as to locate a sample in the working region; a probe carrying RF generating and receiving coils and which can be removably inserted into the other, second end of the bore so as to locate the RF coils adjacent the working volume; and a set of shim coils located in the bore about the working volume and which cooperate with the magnetic field generator to create a magnetic field in the working volume of sufficient uniformity to perform a NMR experiment on a sample characterized in that the RF receiving and generating coils are located in a reduced diameter section of the probe at its leading end; and in that at least some of the shim coils are located on a support surrounding the reduced diameter section of the probe.

2. Apparatus according to claim 1, wherein the shim coil support is coupled, preferably integrally formed, with the sample support.

3. Apparatus according to claim 1 or claim 2, wherein the reduced diameter section of the probe includes other shim coils.

4. Apparatus according to claim 3, wherein the reduced diameter section of the probe includes axial field shim coils.

5. Apparatus according to claim 3, wherein the reduced diameter section of the probe includes radial field shim coils.

6. Apparatus according to any of the preceding claims, wherein the reduced diameter section of the probe terminates at a wider diameter section, the wider diameter section substantially filling the bore cross-section.

7. Apparatus according to claim 6, wherein all the shim coils are located axially spaced from the wider diameter section of the probe.

8. Apparatus according to any of the preceding claims, wherein the reduced diameter section of the probe supports one or more gradient coils.

9. Apparatus according to any of the preceding claims, wherein the sample support comprises a tube.

10. Apparatus according to any of the preceding claims, wherein the sample support includes a mechanism for rotating the sample within the working volume.

11. Apparatus according to any of the preceding claims, wherein the magnetic field generator comprises a superconducting coil.

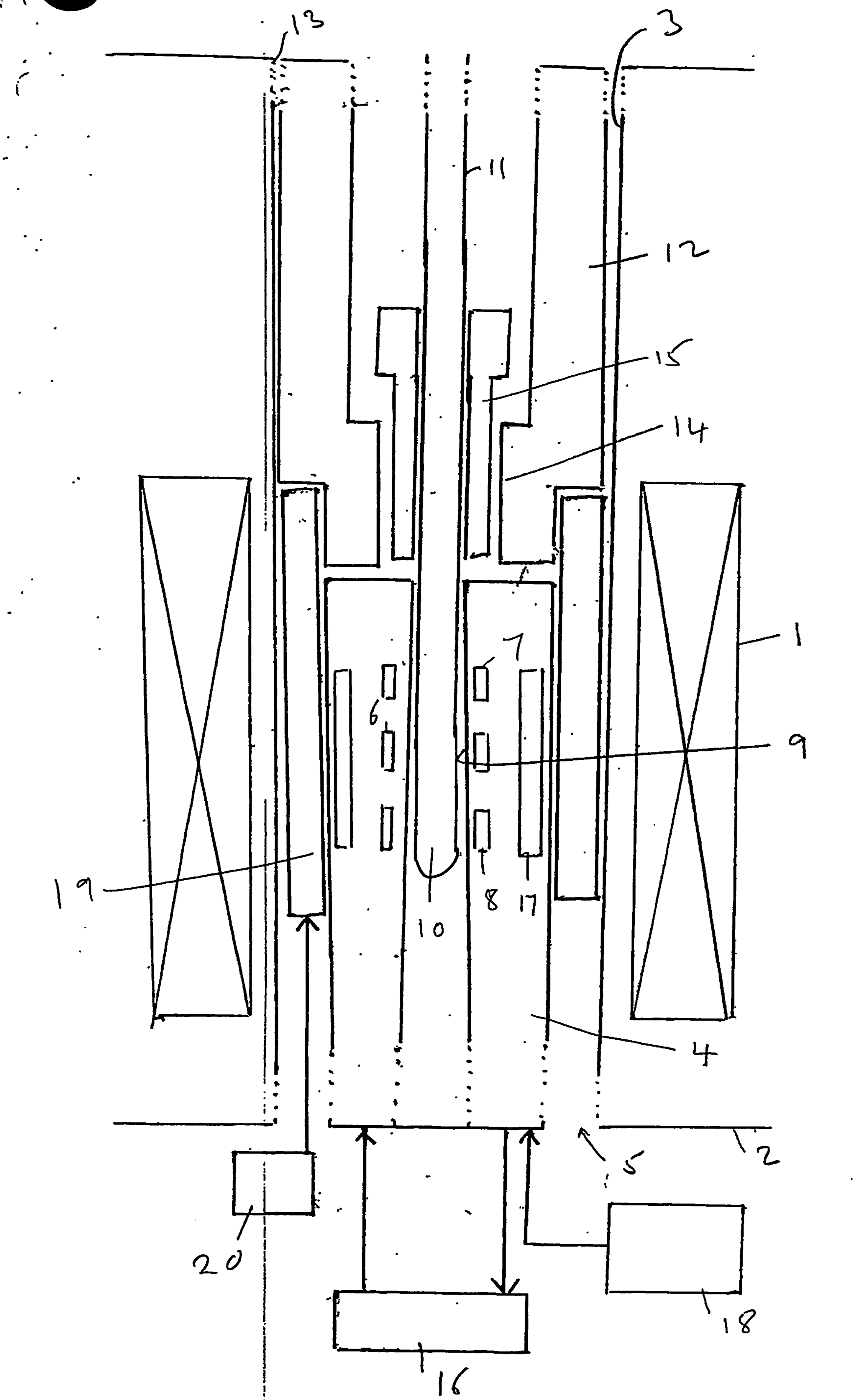

FIG1

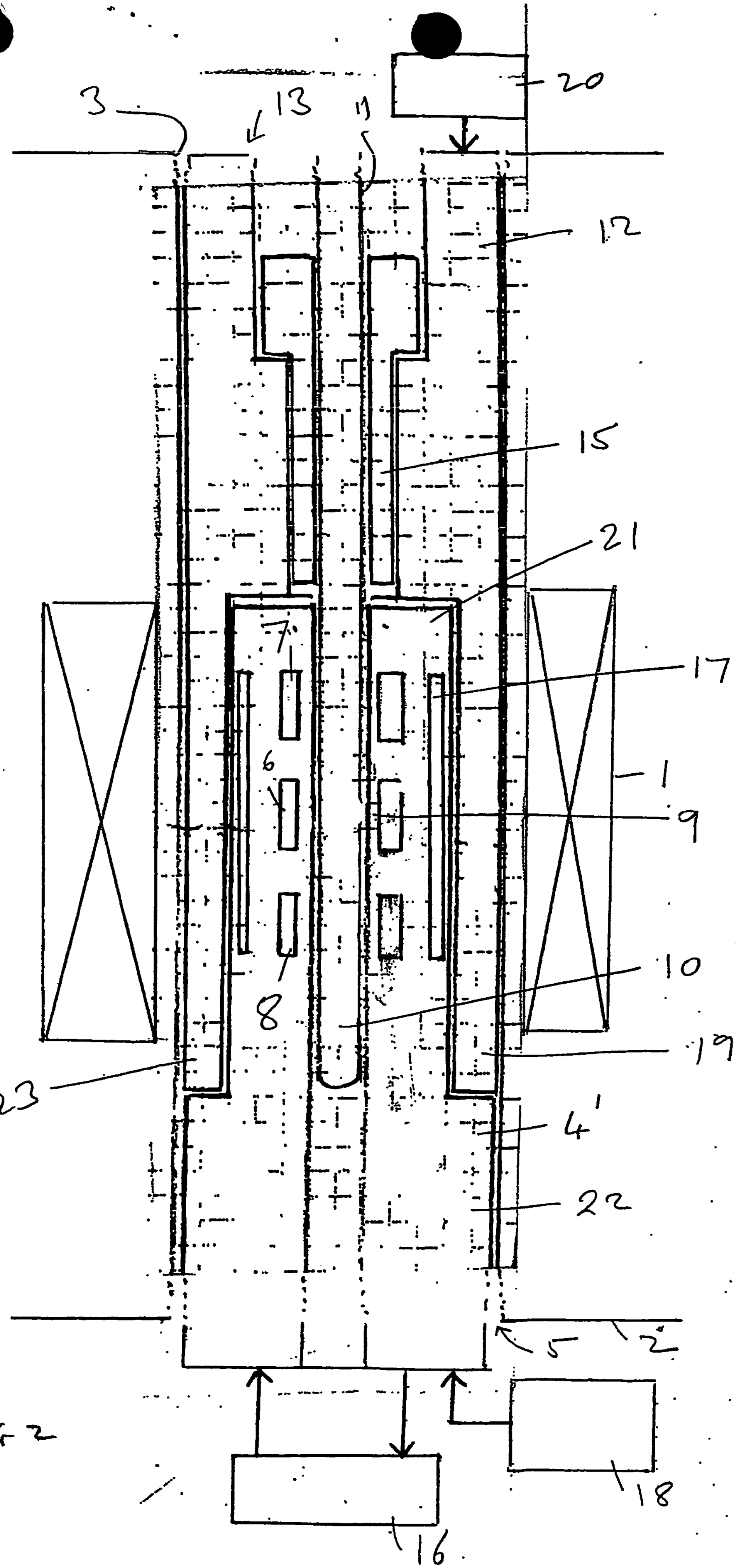

FIG 2

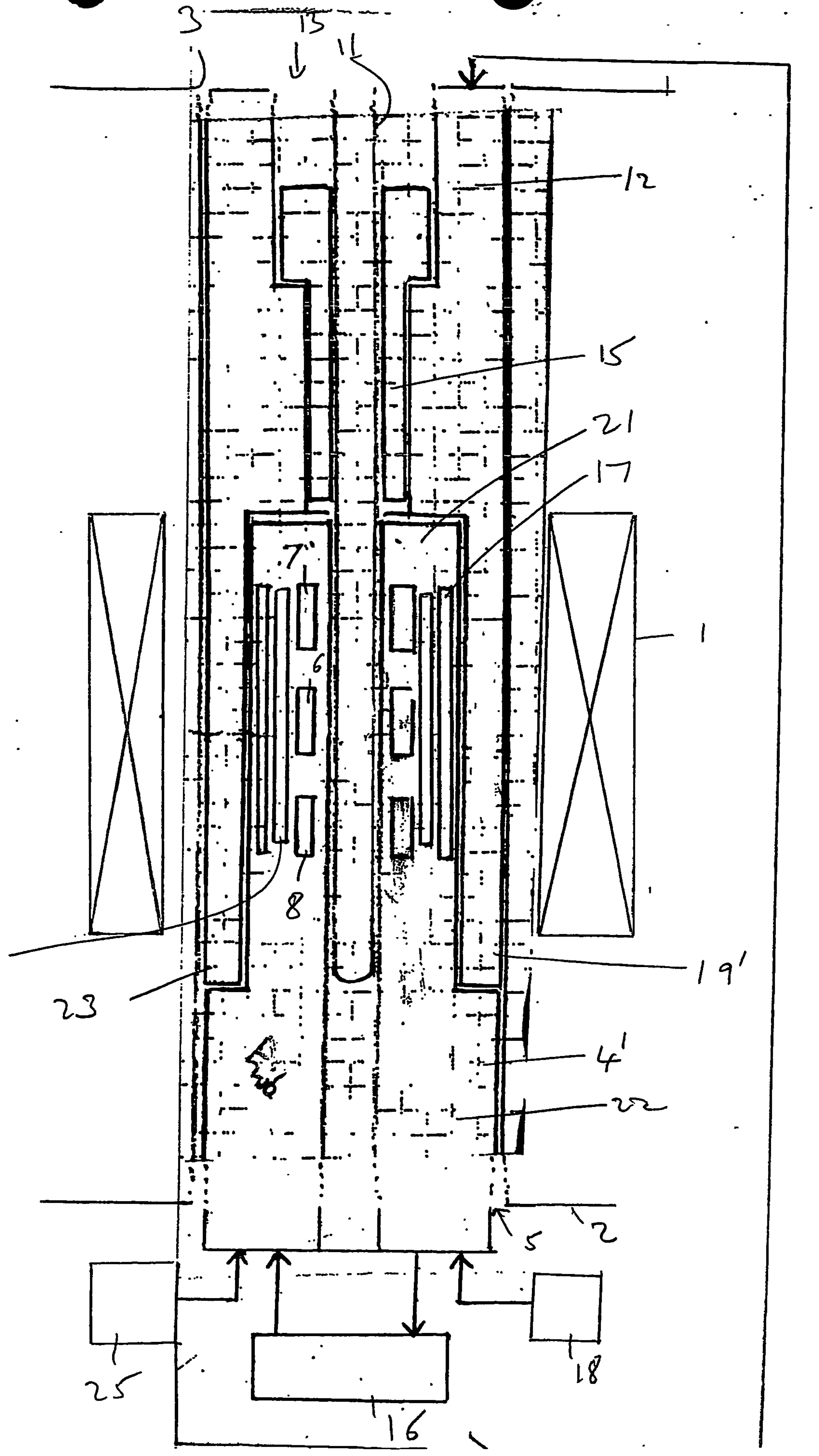

FIG 3